Estimate of Random Kink Background

Introduction

The high density of through-going muons in the emulsion data can give rise to a background to the tau sample, by randomly associating vertex tracks with one of the muon tracks. Only the muon tracks that appear to *start* within the allowed decay volume can be incorrectly linked to those vertex tracks that appear to *stop* within the volume. This memo documents the computation of this background, using data from the set of 203 events.

Method

Outline

The estimation of the random kink background is computed from the product of the starting muon track density per event, ρ, the allowed radius for matching tracks, r_{match}, the number of vertex tracks that stop in the decay volume, N_{stop}, the probability of matching the muon track to the SFT data, P_{SFT}, and the fraction of random kinks that have a "transverse momentum" greater than 250 MeV/c, P_{250}.

$$N_{random} = \rho \cdot \pi r_{match}^{2} \cdot N_{\mathrm{stop}} \cdot P_{\mathrm{SFT}} \cdot P_{250}$$

Muon Track Density

The track density is easily estimated by choosing a point in the decay volume and computing the transverse distance from this point to the track projection. It is convenient to choose the primary vertex as the reference point for the estimate. The track is checked to see that it starts in plate following the vertex, but it is allowed to be missing one segment on the next plate for the ECC type of target, but not for bulk. For tracks that are uncorrelated to the vertex, the distribution of the starting tracks will behave like $dN/dr = 2\pi\rho r$, where r is the transverse distance from the track to the vertex. The density is found from the histogram of r , with the number of entries in each bin scaled by bin width, $dN/dr=N_{bin}/w$, with w in mm.

In this analysis, the background from 1-segment primary tracks is treated separately from the multi-segment primary tracks

Radius for Matching

The distance of closest approach used for joining starting to stopping tracks is set at 5μm, which is approximately 5σ.

Number of Stopping Tracks

The tracks from the primary vertex are accepted as possible random background if they stop in the decay volume less than 5mm from the vertex. The number of these stopping tracks, N_{stop}, is found from all the primary tracks in the set of 203 events using the emulsion files in `/root/data/root` directory on `fnbblx1`. Again, a separate number is determined for 1-segment primary tracks that stop, and multi-segment tracks.

SFT Matching Probability

The probability for matching a random muon track to the SFT data is determined from the 203 event data set in the following manner. The *u* and *v* angles for all SFT lines formed in a given event are compared to the *v* and *u* angles (respectively) of all of the emulsion tracks in the same event. The interchange of *u* and *v* views is used to form an uncorrelated set of angles with respect to the SFT tracks. Offsetting events is another method, but it is desirable to retain the correlation of emulsion track number to the number of SFT lines in the event. Only primary emulsion tracks with angle less than 250 mrad are kept.

Transverse Momentum Distribution

The kink angle for the randomly associated background is known, of course, but the momentum that would be assigned to the "daughter" track is not generally available for all events. A conservative estimate of the momentum of these tracks is from the momentum distribution measured for the small-angle, or “eye” muons, seen in the T1•T3 triggers in the PW7 (normal) data. The estimated p_T distribution (not individual event p_T) is computed using the convolution of the kink angle distribution with the estimated p distribution. This product distribution is used as a probability density for p_T.

Results

The results are derived from the set of 203 events; where ρ , the density of starting tracks is independent of the knowledge about the vertex, but the number of stopping tracks, N_{stop}, is the actual set of primary vertex tracks that are used in the decay search. Thus the estimate is as close as possible to the data itself.

Multi-segment Stopping Tracks from Primary

The value of ρ , derived from Figure 6, is 3.8 tracks mm^{-2} at each side of an emulsion plate. This number assumes that there are exactly 5 sides available per 5mm long fiducial volume, which is a conservative lower limit. The number of stopping tracks, N_{stop}, is found to be 130. This gives a background of N_{bkg}(>1 seg) = 0.012

Single-segment Stopping Tracks from Primary

The value for the density, r, from 1-segment starting tracks is found to be 5.3 mm^{-2}, derived from data shown in Figure 7. Only the plate downstream of the vertex plate is used in this density. The number of stopping tracks is measured to be 44 in the sample of 203. It is possible that many of these 1-segment tracks are randomly associated with the primary vertex. This is computed by displacing the point where track IPs are computed and checking how many of these 1-segment tracks fall within 5mm of the test point. For this study, the test point was displaced 100µm in both u and v, in the same (vertex) plate. The result is that 11 segments are found, implying that most of the 1-segment tracks within 5µm of the primary vertex are, in fact, associated with it. However, since one cannot distinguish background and signal event-by-event, all 44 stopping tracks must be used in the estimate for the random background.

The background from this source is N_{bkg}(1 seg) = 0.005, and the sum of the 1-segment and multi-segment background is

$$\boxed{N_{bkg} = N_{bkg}(>1\text{seg}) + N_{bkg}(1\text{seg}) = 0.017}$$

Matching to SFT

The SFT matching probability is measured to be 1/2.94 = 0.34, assuming a cut of 15 mrad for the difference in angle (in space) between the emulsion and SFT lines. The SFT matching results are shown in Table 1. The distributions of angular difference are shown in Figs. 1 - 5.

	All angles			$\theta < 0.10$		
	sync	async	ratio	sync	async	ratio
$\lvert\Delta\theta\rvert$ < 15 mrad	614	209	2.94	354	161	2.20
$\lvert\Delta\theta\rvert$ < 10 mrad	506	116	4.36	321	98	3.28

Table 1. The number of primary tracks matched to SFT lines in both u and v views. The x view is ignored.

Transverse Momentum Cut

The p_T distribution, assuming that the “daughter” track momentum spectrum is the same as the PW7 muons triggered with T1•T3, is shown in Figure 9. There is very little benefit to a 250 MeV/c cut, and is effectively ignored, setting P_{250} = 1.

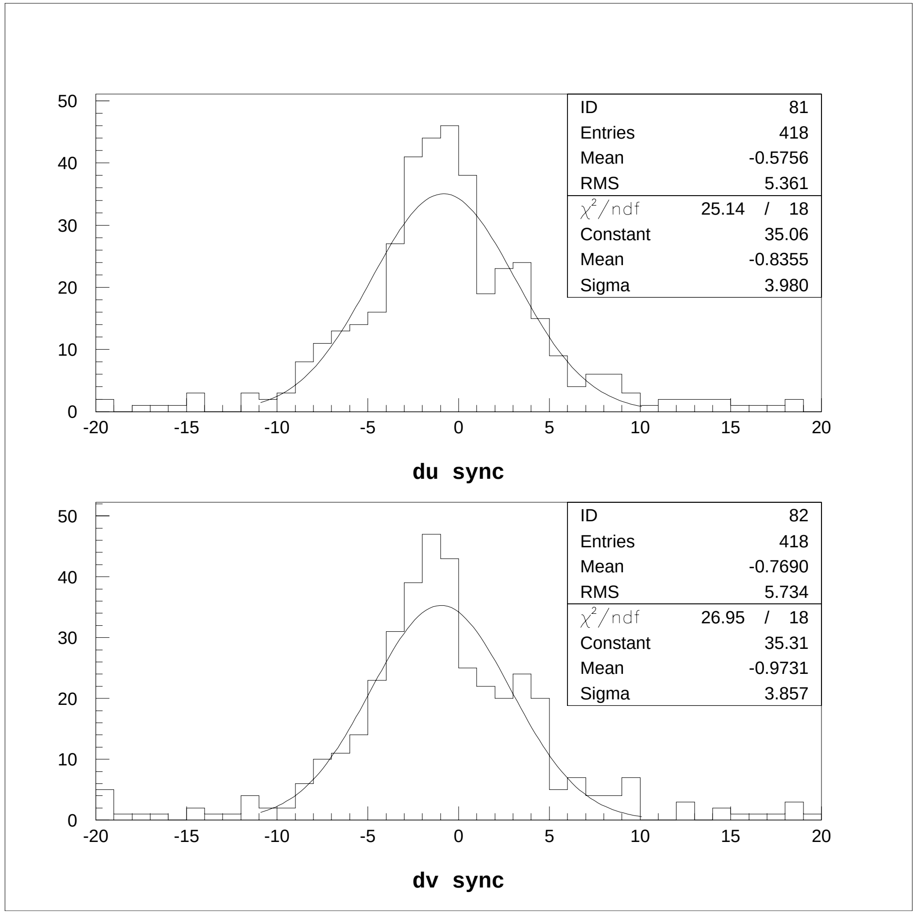

Figure 1. The smallest difference in angle θ_{SFT}- θ_{emul} for tracks in the *u* and *v* views with emulsion track angle less than 100 mrad. In the SFT, all single-view *lines* are used.

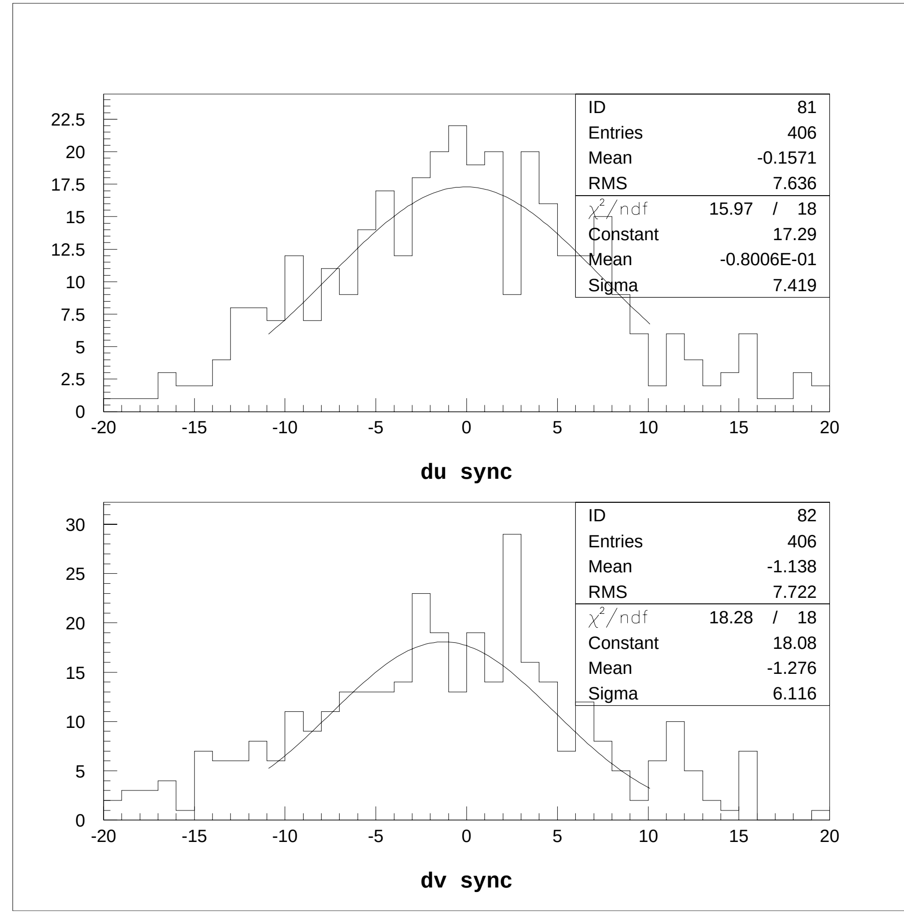

Figure 2. Same as Fig. 1 but without acut on angle.

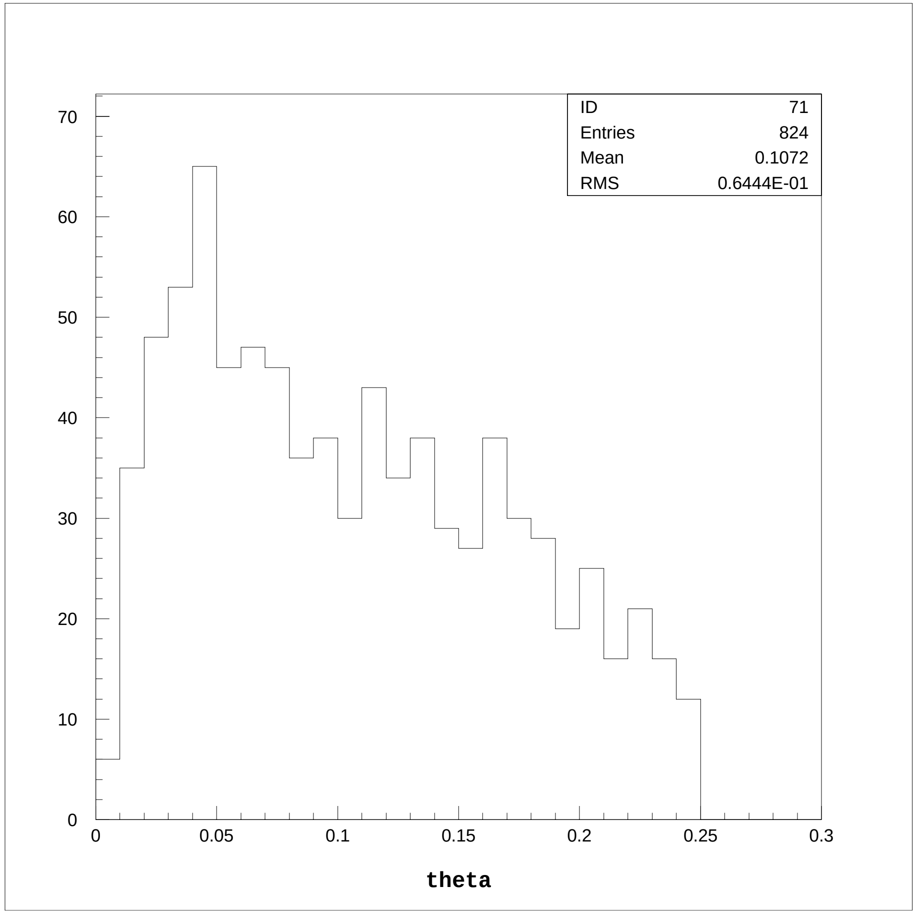

Figure 3. The angular distribution of emulsiontracks in the data sample.

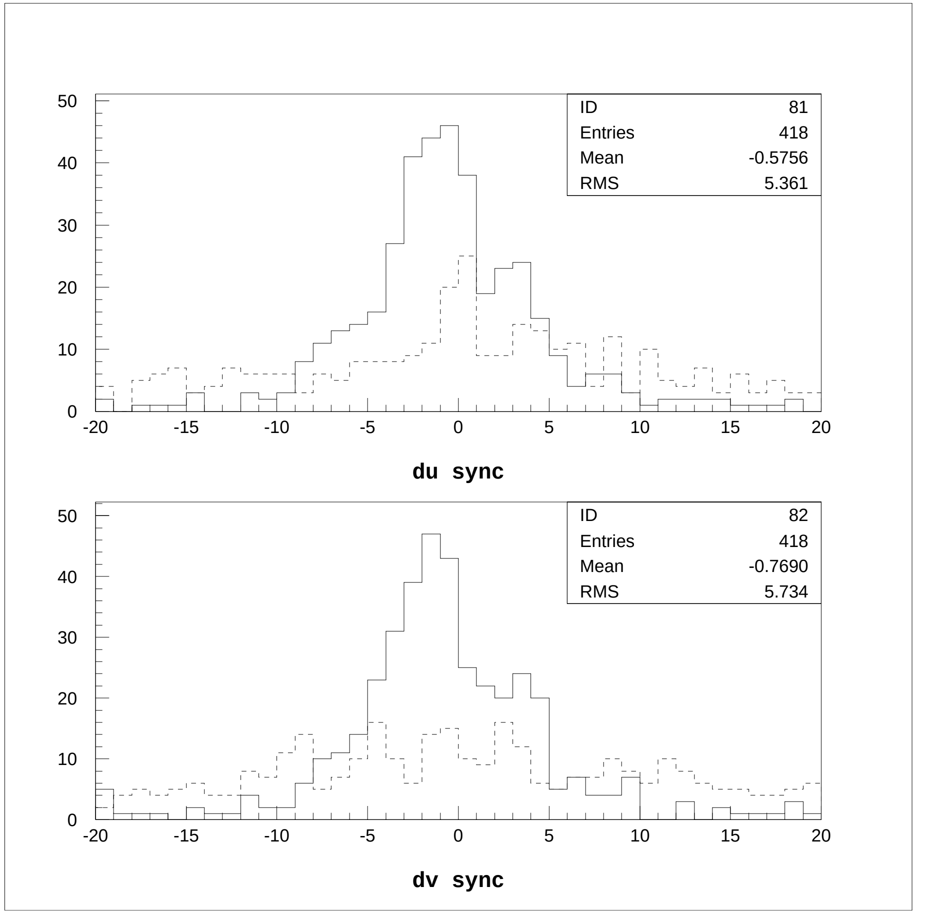

Figure 4. The solid line histogram is the same as in Fig. 1. The dashed histogram (*top*) is formed by plotting the smallest difference between a *u* view track in the SFT and a *v* view track in the emulsion data for the *same* event. For the *bottom* dashed histogram the *u* and *v* views are interchanged.

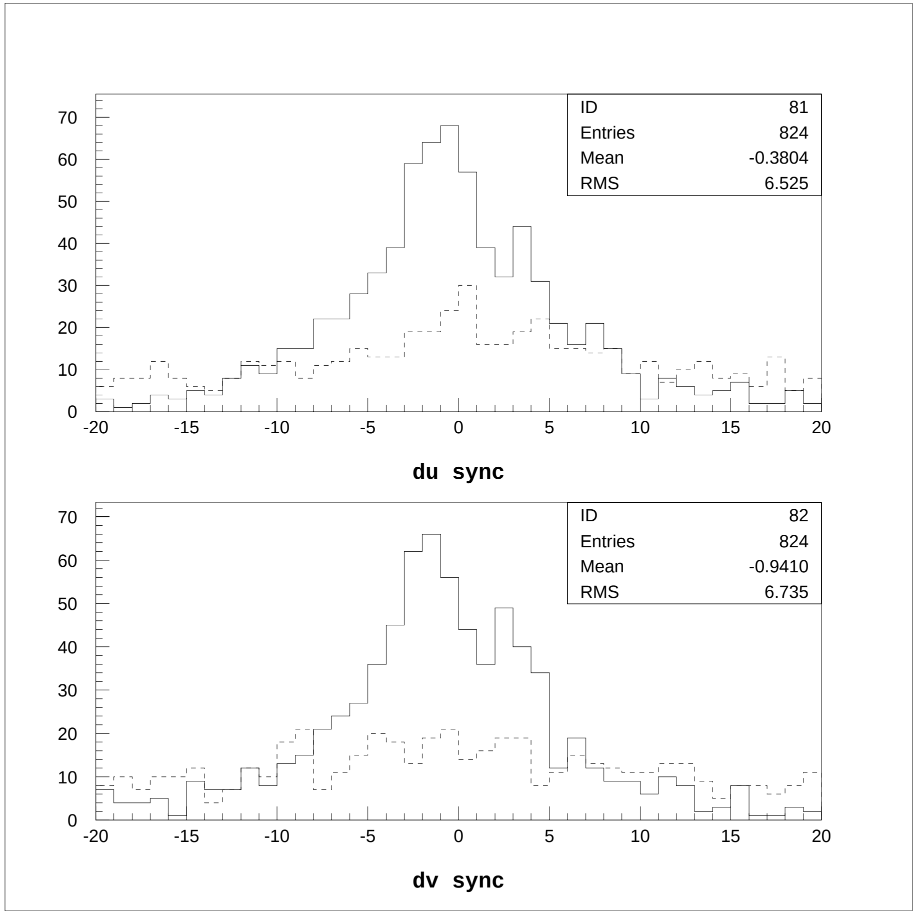

Figure 5. The same as Fig. 4, but for all angles.

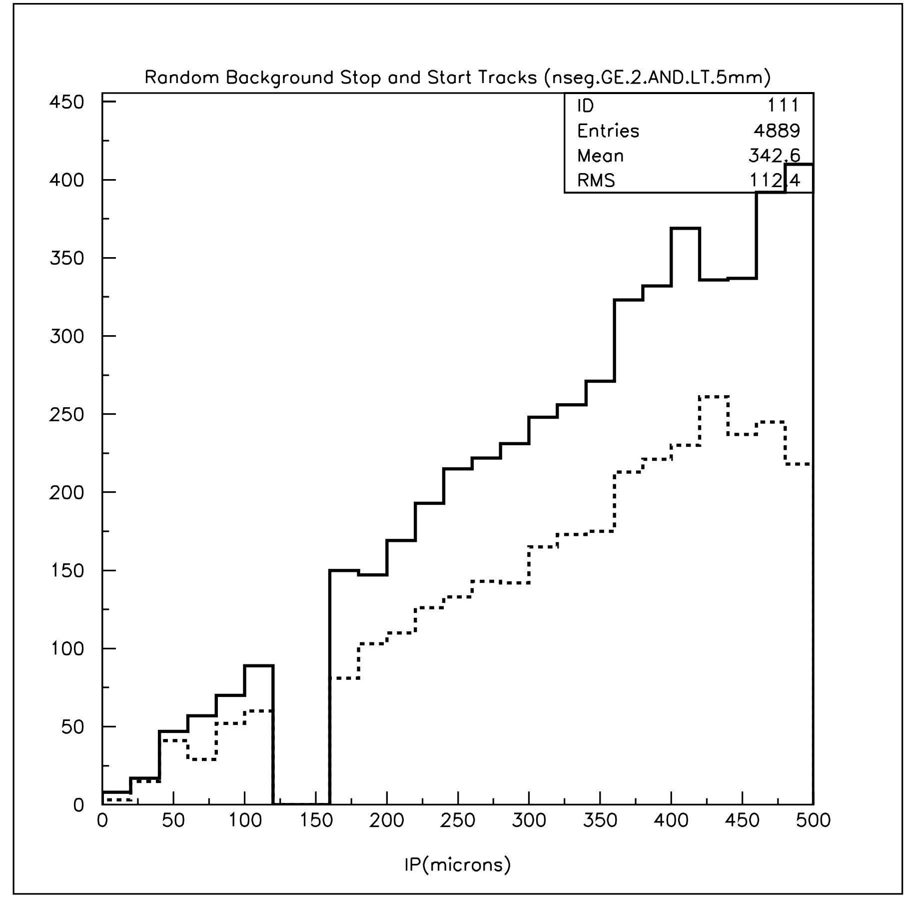

Figure 6. The distribution of IP for starting tracks (*dashed*) with the test point displaced from the true vertex position. The actual primary tracks have been cut from this plot. The data includes all plates less than 5mm from the vertex. The multi-segment stopping tracks (*solid*) are also shown. The density derived for the starting tracks is 3.8mm^{-2}.

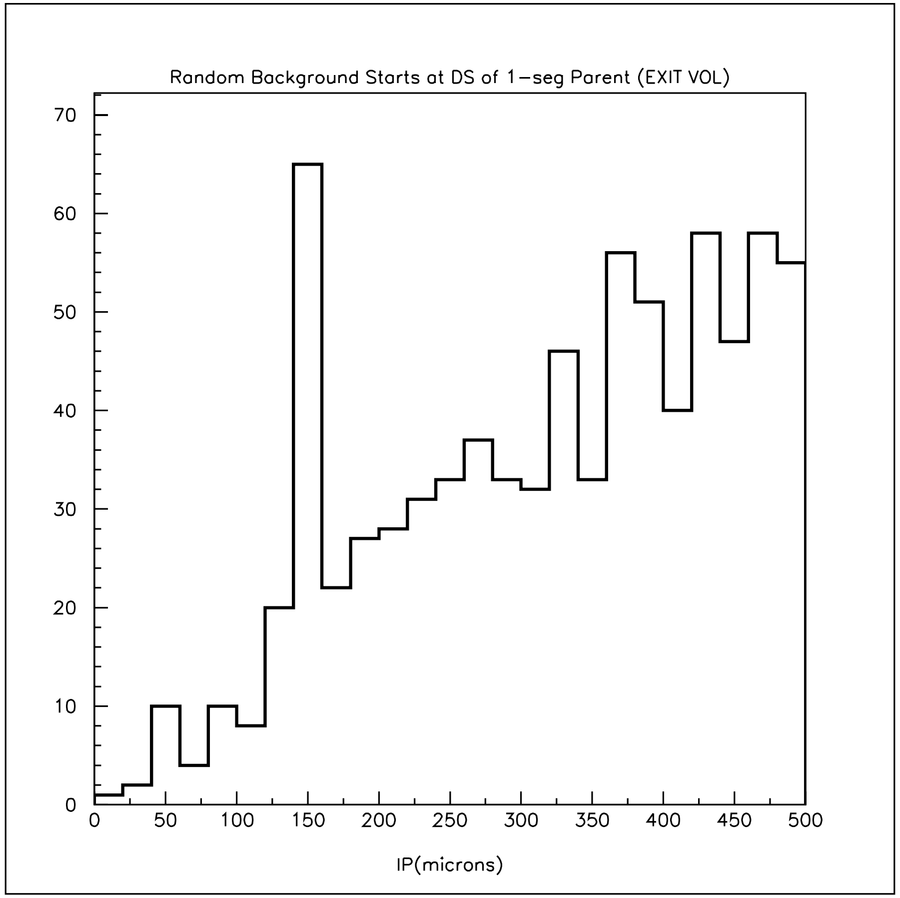

Figure 7. The IP distribution for starting tracks in the plate just downstream of the plate containing a 1-segment stopping track from the primary vertex. The density derived is 5.3 mm^{-2}.

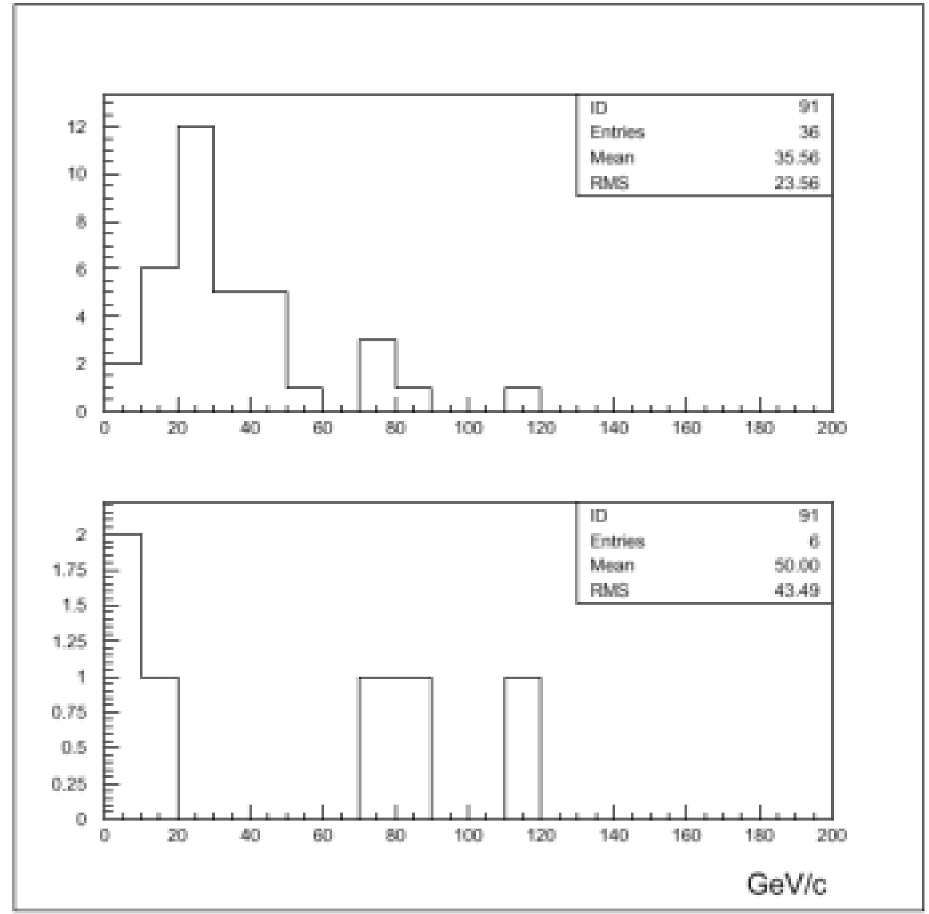

Figure 8. The momenta of PW7 muons in the T1•T3 trigger for negative (*top*) and positive (*bottom*) muons.

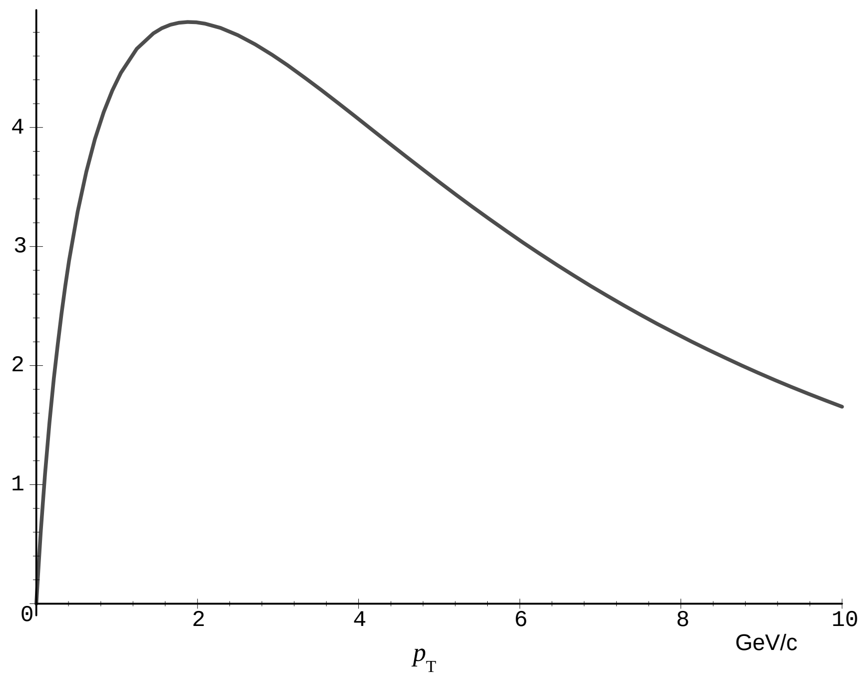

Figure 9, The estimated transverse momentum distribution assuming the momentum distribution of “daughters” from Fig. 8, and the angular distribution of Fig. 3, in which the “kink” angle of the randomly associated tracks is given solely by the “parent”. The starting muons are assumed to have the same distribution as the so-called “eye” tracks, background muons at small angles.